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Sampling and analysis method for measuring airborne coal dust mass in mixtures with limestone (rock) dust

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Abstract

Airborne coal dust mass measurements in underground bituminous coal mines can be challenged by the presence of airborne limestone dust, which is an incombustible dust applied to prevent the propagation of dust explosions. To accurately measure the coal portion of this mixed airborne dust, the National Institute for Occupational Safety and Health (NIOSH) developed a sampling and analysis protocol that used a stainless steel cassette adapted with an isokinetic inlet and the low temperature ashing (LTA) analytical method. The Mine Safety and Health Administration (MSHA) routinely utilizes this LTA method to quantify the incombustible content of bulk dust samples collected from the roof, floor, and ribs of mining entries. The use of the stainless steel cassette with isokinetic inlet allowed NIOSH to adopt the LTA method for the analysis of airborne dust samples. Mixtures of known coal and limestone dust masses were prepared in the laboratory, loaded into the stainless steel cassettes, and analyzed to assess the accuracy of this method. Coal dust mass measurements differed from predicted values by an average of 0.5%, 0.2%, and 0.1% for samples containing 20%, 91%, and 95% limestone dust, respectively. The ability of this method to accurately quantify the laboratory samples confirmed the validity of this method and allowed NIOSH to successfully measure the coal fraction of airborne dust samples collected in an underground coal mine.

Keywords

Coal dust mass; float dust; isokinetic sampling; low temperature ashing; rock dust

Introduction

The largest U.S. mine disaster in several decades was caused by a methane ignition that triggered a massive coal dust explosion.[1] When methane ignites, the pressure gradient from the blast can disperse coal dust from mine entry surfaces. If the dispersed concentrations are

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on the order of 100 g/m^3, a dust explosion may ensue and propagate through the mine.[2,3] Such mechanisms are prevented by applying an inert rock dust so that 80% incombustible content is maintained.[4]

Rock dust is applied at mining faces by hand or by pneumatic hoses.[5] Areas that require larger quantities of rock dust application, such as return entries, are coated by trickle dusters which disperse rock dust directly into the mine air.[6]Rock dust can remain suspended several hundred feet from the source.[7] In addition, deposited rock dust can be re-entrained in mine ventilation air for velocities exceeding threshold friction values[8] or for lower velocities due to instantaneous turbulent velocity fluctuations.[9] Substantial amounts of airborne rock dust may be present and may confound coal dust mass measurements.

Airborne coal dust mass measurements are needed to assess the effectiveness of control technologies for reducing combustible dust hazards in underground mines. Control technologies such as scrubbers and water sprays are developed to prevent coal dust release into mine airways, which lessens coal dust deposition and accumulation on mine surfaces.[10,11] This reduces the potential for a hazardous dust explosion and improves the safety of miners in addition to the protection provided by rock dusting practices. Dust control technologies and rock dusting are often used concurrently, so control technologies need to be evaluated in mine air containing rock dust. Because rock dust is applied in large quantities to meet regulations, a selective direct method is needed to differentiate between airborne coal dust and rock dust masses, and to the authors knowledge no such method has been previously published. Direct measurements based on size classification cannot be used since rock dust and coal dust size distributions overlap.[7] Indirect measurements through chemical mass balance methods would be needed when several overlapping chemical profiles are influential; this previously has been applied to determine earth-metal rock dust contributions to fine ($<2.5\ \mu$m) airborne particulate matter masses in an underground gold mine.[12]

When assessing the mass of explosive size range coal dust, particles up to 74 μm are targeted[13] because larger diameters require relatively high concentrations for ignition and are less likely to initiate an explosion.[2,3,14] Size distributions of ≤ 74 μm airborne coal dust are rarely measured because of challenges with super-micron aerosol sampling.[11] In one study, airborne dust was characterized by isokinetic sampling and analysis of particles collected in a cyclone grit pot.[11] The mean diameter measured downstream of a longwall shearer was 15–35 μm, and the diameter below which 90% of the mass resided ranged from 33–372 μm for three Australian coal mines. Samples in the longwall shearer study were not affected by rock dust because the sampling location was close to the source. However, for dust control technology evaluations, samples must be collected downwind of the longwall and control, in areas treated with rock dust. In previous studies of deposited dust samples, interference from rock dust was eliminated by acid leaching of the dust samples and analyzing the remaining coal dust using a coulter counter or sieve.[15–17] The mass median diameter of *deposited* coal dust in mine return entries was 122–172 μm, and the mass fraction ≤ 74 μm was 27–38% for 50 bituminous U.S. coal mines.[16] The mass of airborne coal dust ≤ 74 μm in mine ventilation returns is also confounded by the presence of rock dust and requires greater measurement selectivity than deposition samples due to the lower mass concentrations of airborne coal dust.

Gram-quantity deposited dust samples were analyzed for incombustible content by low temperature ashing (LTA)[5,18,19] and acid leaching methods.[16] Harris et al.[20] compared LTA methods that preserved limestone while combusting coal but differed by thermal treatment times. Rock and coal dust mixtures were heated at 515°C for 2.5 hr by the Mine Safety and Health Administration (MSHA) National Air and Dust Laboratory (NADL) at Mt. Hope, WV[18] and for 20 hr by the National Institute for Occupational Safety and Health (NIOSH).[19] In addition, the methods differed in moisture removal and sieving protocols, but these preparation procedures were not expected to affect incombustible masses. The MSHA NADL and NIOSH measurements had good agreement with an average 2% difference for samples collected at eight different coal mines. The results suggested that the MSHA NADL analysis provided accurate incombustible mass content although shorter heating time was used. MSHA NADL measurements also agreed with acid-leached masses (1–3% difference) for low, medium, and high volatile content coals.[16] Applying the MSHA NADL method to relatively low mass airborne dust samples may require improved method selectivity.

Sampling cassette type has a significant influence on sample losses and gravimetric analysis resolution. To assess airborne respirable dust concentrations for regulation compliance, an MSHA-approved filter cassette is used with a 10-mm Dorr-Oliver nylon cyclone attached to the cassette inlet. The design is a closed-face cassette with 5-mm inlet that houses a 37-mm polyvinylchloride (PVC) filter (Zefon, Ocala, FL). An aluminum foil cover is crimped onto and weighed along with the filter to prevent losses to the walls of the cassette.[21] The PVC filter ashes during thermal treatment and cannot be weighed separately from its aluminum cover, so the mass of the combustible dust and fiter are tied together. To determine incombustible dust mass for samples collected in the MSHA-approved cassette, dust remaining after ashing can be resuspended in liquid, filtered through a second substrate, dried, and weighed again. Sample transfer of ashed dust is also carried out for determination of crystalline silica and requires care in sample handling and analysis.[22,23] This same filter cassette, used without the cyclone, is also recommended for the collection of large “nuisance” dust samples.[24]

Sample transfer steps as noted above can result in lost mass and/or sample contamination but can be avoided by collecting airborne dust in media unmodified by temperatures encountered in LTA. An inhalable dust sampler developed by Mark and Vincent[25] of the Institute of Occupational Medicine (IOM; Edinburgh, Scotland) is available in stainless steel and can be fitted with a high-temperature quartz-fiber filter in order to withstand thermal treatment for determining combustible content. Negative artifacts from quartz-fiber losses due to air passing through the filter should be much lower than the sample masses since the soft friable edges of the filter are enclosed and sandwiched by the cassette. The IOM sampling cassette and filter assembly are weighed together, so that dust depositing on the walls is included in gravimetric analysis. Including wall deposits was shown to be especially important for large particles.[25,26] The stainless steel cassette weighs multiple grams and requires a wide-resolution microbalance and controlled weighing conditions to accurately determine collected particle masses.[26]

With the above considerations in mind, a method was developed for measuring airborne coal dust mass in samples containing limestone rock dust. Homogenous coal and rock dust incombustible fractions were used to estimate the mass of coal dust in mixed samples. Incombustible fractions were measured by the modified LTA method of the MSHA NADL[18,20] and by analyzing samples in a humidity- and temperature-controlled weighing chamber with a wide-resolution microbalance. The method was evaluated for sample masses of 40–500 mg and rock dust fractions of 20%, 91%, and 95% in the laboratory, and was subsequently tested in the field for relatively low coal dust concentrations downwind of a scrubber.

Methods

IOM cassettes containing 40–500 mg rock and coal dust were treated by LTA and weighed in a humidity- and temperature-controlled chamber with a wide-resolution microbalance (310 g to 0.1 mg) to determine incombustible content. Homogeneous sample incombustible fractions were used to estimate the mass of coal dust in mixtures with rock dust. The coal dust mass estimation method was applied to airborne dust samples acquired in an underground coal mine downwind of a scrubber. The weighing procedures and coal dust mass estimation methods are described in what follows.

Dust characteristics

Pittsburgh pulverized coal (PPC) dust ≤ 74 µm was used for the method evaluation. It is a mid-rank (medium volatile matter; medium ash) bituminous coal, which must be mined with adherence to dust explosion regulations due to the volatile hydrocarbon content. Rock dust used for the evaluation followed regulation specifications.[27] It consisted of pulverized limestone with at least 70% mass in the ≤ 74 µm size range (Allegheny Mineral Corp., Kittanning, PA). Limestone dust is typically used for explosion mitigation since it is widely available and inexpensive. Coal and rock dust mixtures with 20%, 91%, and 95% (mass) rock dust were prepared using a pestle and mortar.

LTA

Stainless steel IOM cassettes were fitted with 25-mm binder-free quartz-fiber filters. When exposed to the 2 lpm field sampling flow rate, blank quartz-fiber filters housed in the IOM cassettes experienced negligible mass loss relative to the range of sample masses in the current study. For a study involving smaller sample masses, the quartz fiber mass loss should be measured for a statistically significant number of cassettes and quantified. The IOM assemblies were heated in a muffle furnace for 2.5 hr at 515°C to vaporize organics before loading dust samples. After de-greening, the assemblies were equilibrated for 12 hr in a humidity- (52%) and temperature-controlled (23°C) chamber and were weighed using an Ohaus AP310 microbalance with 310 g capacity and 0.1-mg resolution (Parsippany, NJ). Homogeneous and mixed samples with masses of 40 mg to 500 mg were loaded by transferring powders into the IOM cassette with a spatula. The loaded cassettes were weighed following a 1 min residence time in an electrostatic deionizer and 1 min settling time in the microbalance. With longer residence time in the deionizer, mass results remained the same most likely because the metal cassette readily discharged electrostatic charge accumulation. Moisture was removed by heating at 105°C for 2 hr. Dry samples were re-weighed and moisture content was found to be negligible. Samples were ramped to set-point over about 1.5 hr and were heated in air at 515°C for 2.5 hr in a muffle furnace. The temperature-time treatment of the samples was approximately the same as in the MSHA NADL analysis.[18] The samples in the current study underwent heating 1 hr longer at 105°C, but there was negligible change in mass, so the methods should be equivalent. In addition, coal dust in the current study may have contained smaller particles since samples were sieved to less than 75 μm, rather than less than 841 μm as done by MSHA NADL.[20] The presence of smaller size dust in the current study would improve ashing and not hinder the method. However, 2–25 times smaller sample masses required greater mass measurement sensitivity. LTA sensitivity was improved by gravimetrically analyzing samples in a humidity- and temperature-controlled chamber and with a wide-resolution microbalance (310 g to 0.1 mg) as described above.

Coal and rock dust mixtures were evaluated for incombustible mass fraction. The following equations were used to calculate the mass of coal dust in the mixed samples:

$$M_T = M_C + M_R \quad (1)$$

$$M_I = F_{IC} M_C + F_{IR} M_R \quad (2)$$

where M_T is total dust mass, M_C is coal dust mass, M_R is rock dust mass, M_I is incombustible dust mass, F_{IC} is the incombustible fraction of homogeneous coal dust, and F_{IR} is the incombustible fraction of homogeneous rock dust. Inputting (1) into (2) gives coal dust mass based on measured values:

$$M_C = \frac{F_{IR} M_T - M_I}{F_{IR} - F_{IC}} \quad (3)$$

Weighing mixed samples before and after heating provided total and incombustible dust masses. The incombustible fractions of coal and rock dust were determined by LTA of homogeneous samples. The solution provided coal dust mass in mixed samples with rock dust.

Isokinetic sampler

As in previous underground mine, atmospheric, and personal sampling studies, isokinetic sampling[28] was pursued to representatively collect total airborne dust (e.g., Barker and Humphreys;[11] Wedding et al.;[29] Kenny et al.[30]). An isokinetic sample was obtained by adapting a nozzle to the inlet of a stainless steel IOM cassette. The nozzle was attached using a 3-D printer constructed, threaded adapter with O-ring seals at the nozzle outlet, the IOM cassette top, and the cassette holder rim (Figure 1). The adapter was constructed using a 3-D printer with acrylonitrile butadiene styrene polymer. Particle losses from electrostatic effects were prevented by overlapping the stainless steel isokinetic nozzle and the inlet of the stainless steel IOM cassette, so that the aerosol traversed the conductive material. The sampler was operated at 2 lpm, a flow rate compatible with intrinsically safe pumps for use in coal mines. The adapters were leak-tested with less than 2% difference in pre- and post-sampler flow rates.

The isokinetic nozzle specifications followed some EPA Method 5 guidelines with a less than 30° angle at the thin-walled inlet and constant inner diameter (ID) through the stainless steel tube.[31] A straight-walled probe was used rather than a button hook or elbow design so that coarse particles would pass through the inlet and deposit in the IOM cassette rather than depositing in the curved probe from inertial effects. For the moderate mine air velocity of 2.9 m/s, the isokinetic nozzle ID was 3.86 ± 0.37 mm. Since large coarse particles were targeted, there was significant potential for sedimentation in the nozzle. Limited measurements of dust mass deposition suggested that about 4-cm length nozzles were required to keep losses under 10%. For these measurements, the test dust volume median diameter (48 μm) was larger than airborne dust measured in three underground coal mines at the longwall face (15–35 μm),[11] so the dust had a greater tendency to deposit and provide a challenge to the inlet. The diameter below which 90% of the total dust volume resided (d_{90}) was 104 μm, which was greater than or close to most of the measurements made in the three underground mines. Although one d_{90} measurement was as large as 372 μm,[11] which includes coal dust diameters that are nonexplosive (>250 um),[13] this was not common. Future work may involve determining the optimum nozzle length and diameter such that particles larger than the explosive size range would tend to settle in the inlet. Since very large, nonexplosive size range particles were not common in the previously reported size distributions,[14] a size selective inlet was not pursued in the current study.

Field sampling

In the field test, NIOSH sampled in the return entry on a continuous miner section, with the primary source of airborne coal dust resulting from cutting at the coal face with a continuous miner. Rock dusting in a portion of the return entry was suspended during the NIOSH sampling periods in an effort to avoid contamination of the coal dust samples. However, airborne rock dust contamination was present due to surface re-entrainment from the large quantities of rock dust found on return entry surfaces, with roughly a 4-in layer on the mine floor (Figure 2). To assist in quantifying the coal product fraction in the airborne samples, NIOSH collected an uncontaminated sample of bulk coal at the mining face. For each day of sampling, coal was scooped from the conveyor boom of the continuous miner into a jar (grab sample) and ultimately sieved to ≤ 74 μm for analysis. Coal product was obtained by grab sampling because of limited mine access. With more space for mixing and partitioning bulk coal and additional time permitted in the mine, a composite sample can be produced using a protocol involving cone and quartering.[32] Rather, it was approximated that material mined along with the coal (clay and/or rock) would be present in the grab sample as well as airborne dust, and using the incombustible content of the product mined on the given day of sampling would be representative of the coal mine dust challenging the dust control system. This is because the grab sample was directly sieved for sub-75 particles, rather than crushed and ground from the relatively homogenous coal pieces. The sub-75 micron particles were used for the analysis, and the larger grains and lumps of coal which tend to be more homogenous, were excluded. The smaller dust tends to include more impurities which is more representative of the airborne dust.

Since control system efficiency is a strong function of particle size, rather than composition, coal dust with impurities generated by the mining process will be scrubbed, and the highly abundant limestone dust added after the control system should be factored out for the assessment. Similarly, because of lack of mine access for preparing a composite sample, an uncontaminated bulk sample of rock dust was obtained on each day of airborne dust sampling by collecting a grab sample at the rock duster in the return entry.

Sets of three samplers shown in Figure 3 were mounted 200 ft (61 m), 300 ft (91 m), and 400 ft (122 m) downwind of a flooded-bed scrubber.[33] Air velocities were measured for each position downwind and were within 15% of the isokinetic sampling velocity. In a previous study, sampling within 15% of the isokinetic velocity led to coal dust masses within 20% of the isokinetically collected mass for measurements with a cyclone dust probe.[11]

Nozzle caps were removed and sampling pumps were started before the continuous miner began cutting coal. Sample pumps remained on until the continuous miner completed cutting. Researchers moved downwind of the samplers to avoid re-entraining rock dust deposits. Samplers were handled and transported in an upright position to avoid dust losses to the cap. Custom case inserts were used to keep the samplers from shifting or tipping during transport from the mine. The IOM assemblies were equilibrated for 12 hr in a humidity- (52%) and temperature-controlled (23°C) chamber and were weighed using the Ohaus microbalance. LTA analyses of these samples were then completed using the method described previously.

Results and discussion

LTA

For the method evaluation, gravimetric measurements of coal dust mass were compared with estimates using (3). Estimation required incombustible fraction measurements of homogenous coal and rock dust. This was determined by loading IOM assemblies with homogenous PPC and limestone dust and thermally treating the samples following the MSHA NADL protocol. The incombustible fraction is thus method-specific and is not a certified value for the material. Since the homogenous and mixed samples undergo the temperature-time history, the incombustible fractions should be consistent. Homogeneous PPC dust incombustible content was found to be 8.2% ± 0.6% by LTA. To get a complimentary measurement using an alternative method, the incombustible fraction was measured by thermo-gravimetric analysis (TGA). A Q500 TGA (TA Instruments, Inc.) was used to heat the samples 20°C/min, and incombustible content was determined from the TGA profile. Results are shown in Figure 4a, in which the mass fraction was stable at 8.05% —-a value within our 95% confidence intervals. Limestone dust incombustible content was 99.1% ±0.2%, which is consistent with the Q500 TGA profile value at 515°C (99.48%, Figure 4b). An exact comparison was not intended since the Q500 TGA had a relatively fast ramping time (20°/min).

In addition to homogenous incombustible fractions, mixture total mass and mixture incombustible mass are required for (3). Mixtures with 20%, 91%, and 95% rock dust were prepared by pestle and mortar, loaded in IOM assemblies, and gravimetrically analyzed to determine total mass. Mixture incombustible mass was determined by weighing after thermal treatment. With the above measurements, coal dust mass could be estimated using (3). Coal dust mass estimates were very close to actual values as shown in Figure 5. For total dust samples that ranged from 40–500 mg, the average difference between estimated and actual coal dust masses are given in Table 1 for 20%, 91%, and 95% rock dust. Estimated values were slightly lower than actual coal dust masses, as expected from the incombustible content results. As shown in Table 1, all differences were less than 1% including 95% confidence intervals. Thus, the method provided an accurate estimate of coal dust mass in mixtures with rock dust and was sensitive for high rock dust fractions.

Homogenous and mixed samples underwent the same temperature/time history, so coal dust incombustible mass fraction should remain the same whether coal dust is homogenous or mixed with rock dust. This is true unless coal dust samples are incompletely combusted at 515°C after 2.5 hr, and there is a catalytic effect by $CaCO_3$ (limestone) when coal dust is mixed with limestone dust as reviewed by Norton.[34] If limestone had a catalytic effect, mixture incombustible mass would be less than that estimated using homogenous sample incombustible fractions. However, the opposite was found. Incombustible masses for the mixtures were slightly higher than that estimated from mass input to the IOM and the homogeneous sample incombustible fractions (Table 1).

These laboratory results suggested that LTA of IOM samples could be used to assess airborne coal dust concentrations in mines applying pulverized limestone dust for explosion prevention. The LTA method for surface deposits was effectively extended to relatively low-mass airborne dust samples because (1) the IOM cassette mass was low enough to provide good dust mass resolution, (2) cassette wall deposits were included in the analysis, (3) dust was sampled and analyzed in the same vessel to avoid transfer losses, and (4) samples were gravimetrically analyzed in a humidity- and temperature-controlled chamber with a wide-resolution microbalance.

Field sampling

The coal dust mass estimation method was applied to field samples collected within 15% of the isokinetic sampling velocity downwind of a dust scrubber. Although EPA Method 5 recommends no more than 10% deviation from the isokinetic value, this may not be practical to achieve because of mine air velocity fluctuations during the sampling period. Air velocity fluctuations are integral to the mining process as the result of varying obstructions in the air course or entry. For example, based on ultrasonic velocity transducer measurements across an entry, the presence of one mine worker caused a 15% increase in average mine air velocity, and one worker in an equipment carrier cart caused a 22% increase.[35] Considering work activity in the mine, a 15% deviation during the sampling period can be expected. When the sampling velocity is lower than the mine air velocity, large particles are over-sampled, and when the sampling velocity is higher, large particles are under-sampled. Although individual coal and rock dust size distributions were not measured, rock dust tends to have larger size particles and would be over or under collected in greater amounts than coal dust. However, since the objective was to measure the relative reduction in coal dust with scrubber operation, the over or under collection of rock dust should not be important. If coal dust is over or under sampled, the scrubber performance evaluation would be affected, so averaging over velocity fluctuations was carried out to provide a more accurate coal dust mass estimate.

Coal dust mass was estimated using (3) and the fraction of rock dust from (1). When the scrubber was not operating, coal dust concentrations were elevated and rock dust fractions ranged from 8–29% (Figure 6). With the scrubber operating, coal dust concentrations were reduced and had greater variability, so rock dust fractions increased and had a wider range, 24–91% (Figure 6). The values were within the range of rock dust fractions evaluated in the laboratory, so we can expect that the method was accurate in estimating coal dust mass.

The results suggest that the rock dust correction method can be used to assess airborne coal dust mass for control technology evaluations. The method can be applied in mines that use pulverized limestone for rock dusting and in which rock dusting can be suspended during the desired sampling periods.

Conclusions

Rock dusting is required in all underground bituminous coal mines in the U.S. for explosion prevention. NIOSH conducted airborne dust sampling in an underground coal mine to assess the performance of a dust scrubber, but a significant fraction of rock dust was present in airborne dust samples due to surface re-entrainment. The fraction increased when a coal dust scrubber was employed, so a sensitive method was required to differentiate between rock and coal dust masses. The MSHA NADL LTA method used for gram-quantity surface samples was extended to airborne dust samples by gravimetric analysis in a humidity- and temperature-controlled chamber with a wide-resolution microbalance. Sample losses and handling errors were avoided by collecting and analyzing dust in the same vessel using an IOM cassette with quartz-fiber filter. Coal dust mass was determined by measuring the incombustible fractions of homogeneous rock and coal dust, the total dust mass, and the incombustible dust mass after thermal treatment by LTA (3).

Including 95% confidence intervals, the difference between actual coal dust mass and that estimated using (3) was less than 1% for rock dust fractions up to 95%. The laboratory-derived method enabled accurate determination of coal dust mass in the presence of rock dust. The fractions of rock dust evaluated in the laboratory were consistent with values found downwind of a scrubber in a continuous miner return. The method described here made possible assessing airborne coal dust concentrations in the field so that a prototype control technology could be evaluated.

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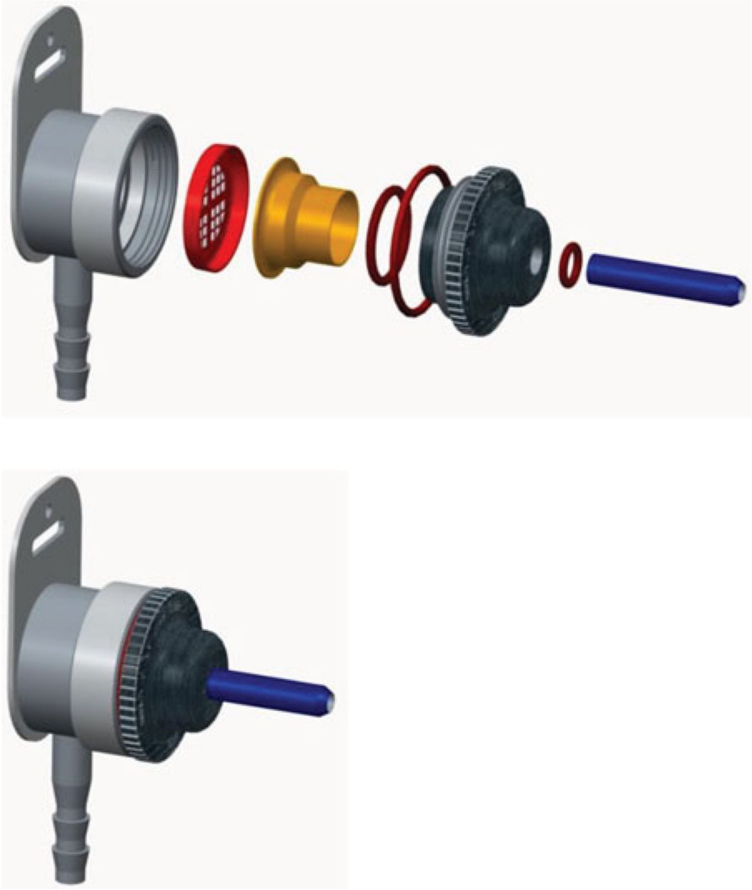

Figure 1.

The IOM sampler adapted with an isokinetic nozzle. The standard holder is in gray, standard filter cassette in red and gold, O-rings in brown, threaded adapter in black, and isokinetic nozzle in blue. (top) Expanded and (bottom) assembled views.

Figure 2.

Rock dust deposits on the roof, ribs, and mine floor at a field sampling location in a continuous miner air ventilation return.

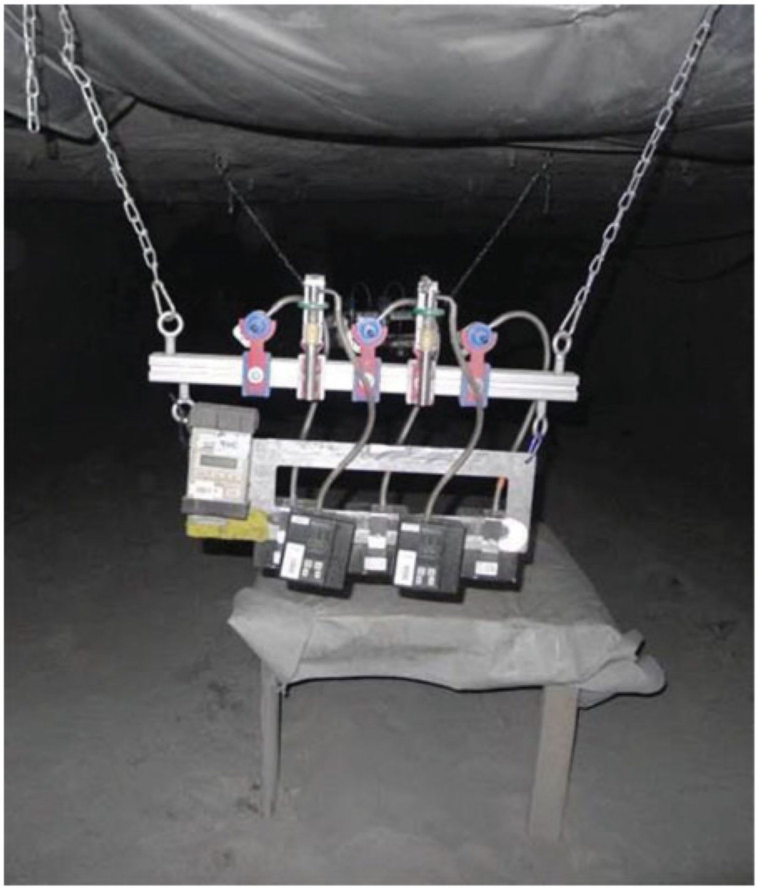

Figure 3.

Isokinetic field samplers (blue) downwind of a dust scrubber in a continuous miner return.

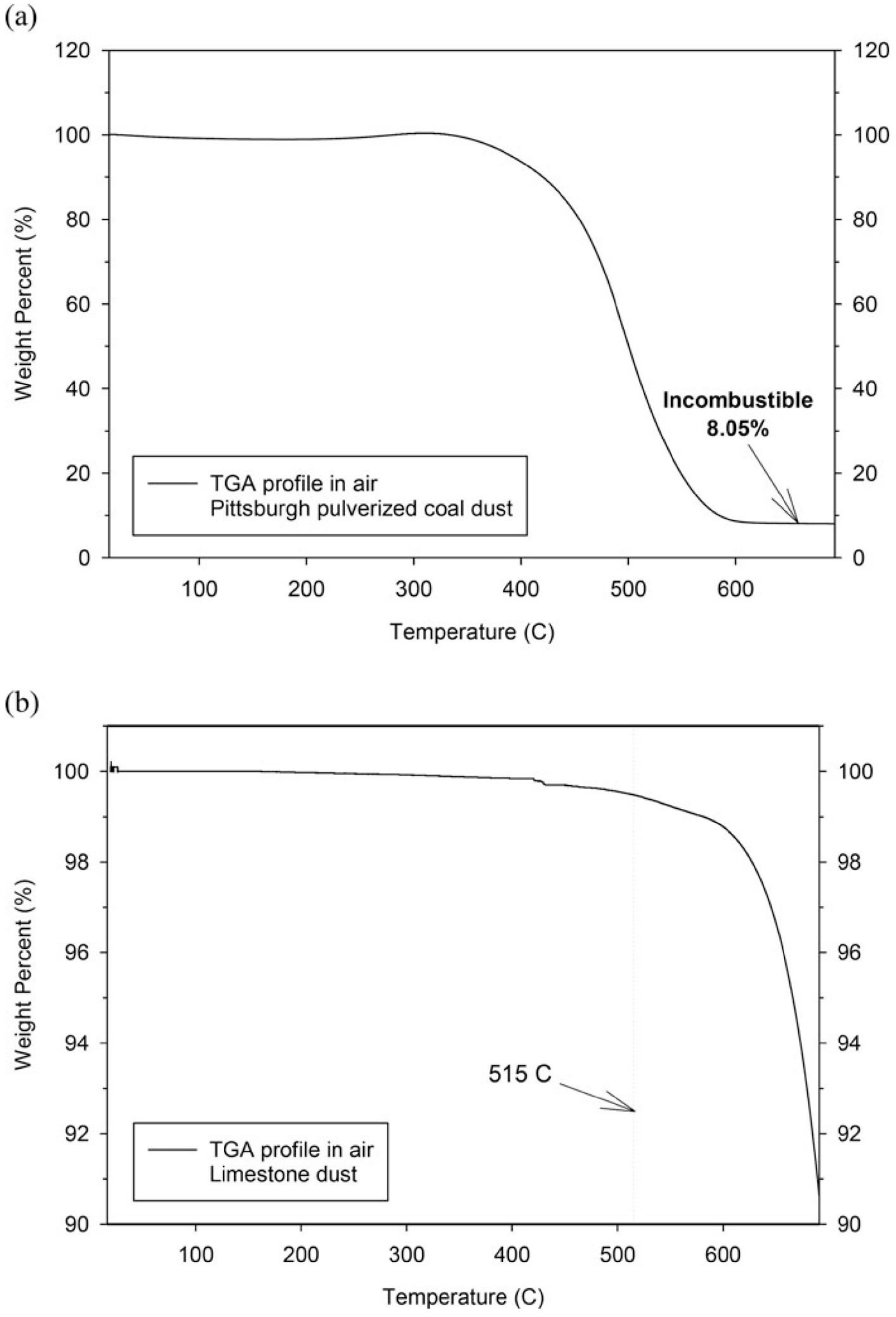

Figure 4.

TGA profile in air measured by Q500 (TA Instruments) for (a) Pittsburgh pulverized coal dust and (b) limestone dust. The rate of temperature increase was 20°per minute.

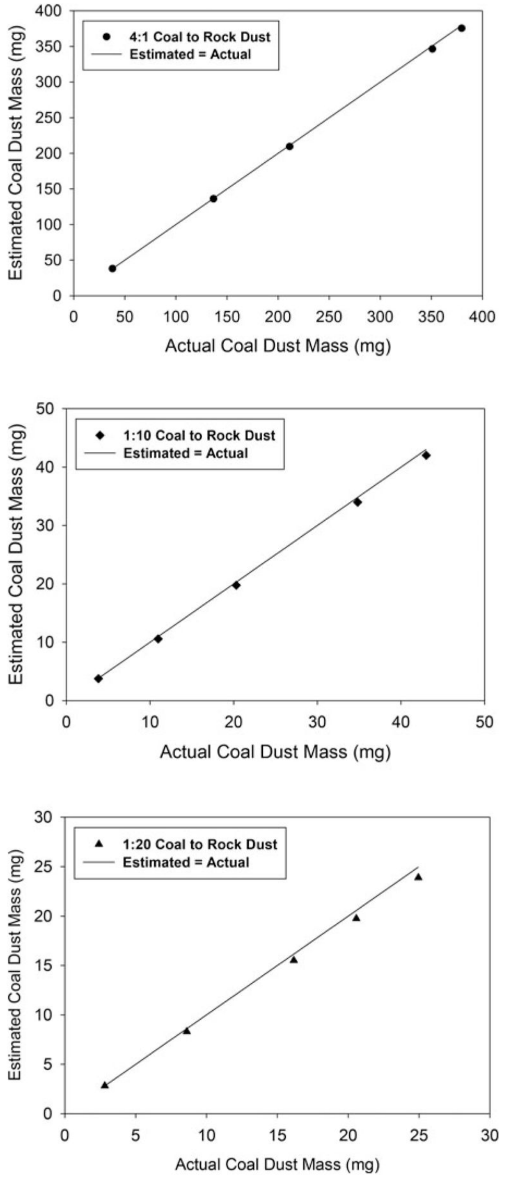

Figure 5.

Comparison of actual coal dust mass loaded in IOM cassette to estimated mass using Equation (3). Estimates (data points) are similar to actual values (lines); percentage difference and error are given in Table 1.

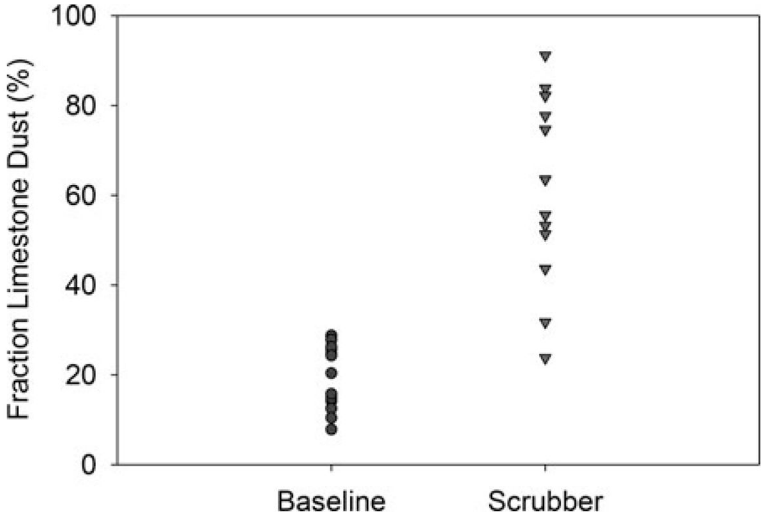

Figure 6.

Fraction of rock dust present in airborne dust samples in a continuous miner air return 200–400 ft (61–122 m) downwind of a scrubber. Baseline tests were done while the scrubber was not operating. Samples contained higher fractions of rock dust when airborne coal dust was reduced by the scrubber.

Table 1

Percentage difference between actual and estimated dust masses.

Mass fraction rock dust	20%	91%	95%
Incombustible dust	0.5 (0.9)	0.2 (0.1)	0.1 (0.1)
Coal dust	0.2 (0.4)	0.06 (0.07)	0.06 (0.08)

Notes: 95% confidence intervals given in parentheses.